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(54) **Data transmission in an sdh network**

(57) A method for the transmission of data in a synchronous digital hierarchy (SDH) network comprising the steps of transmitting to a node of the network a form of data signal from outside the network, converting the signal into a virtually concatenated information structure and transporting the signal through the network in the virtually concatenated information structure; means for carrying out the method and tributary cards arranged and configured to process signals received in contiguously concatenated form to convert them into virtually concatenated form for transfer across the network; thus providing for data transmitted in high-bandwidth, contiguously concatenated signals (ie VC-4-4c) to be transported across a SDH network, not itself capable of carrying contiguously concatenated signals.

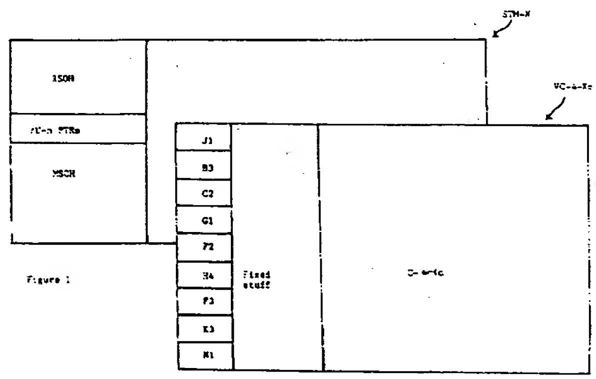

Figure 1

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Description

SUMMARY

[0001] A method for virtual concatenation whereby four VC-4 virtual containers can be associated with one another for transport across a SDH network not supporting conventional contiguous concatenation. Conversion between contiguous and virtual concatenation is achieved by processing bytes of the signal path overhead, for which a new design of tributary card is proposed. Transport through the SDH network is controlled by network management software. The advantage being that higher-bandwidth, contiguously concatenated signals (e.g. VC-4-4c) can be transported across SDH without expensive modifications to the equipment.

[0002] The present invention applies equally to signals and information structures other than VC-4, for example to VC-3, VC-2 and VC-1.

DATA TRANSMISSION IN AN SDH NETWORK

[0003] The present invention relates to the field of synchronous digital hierarchy (SDH) networks and data transmission therein.

[0004] In SDH data is transferred in information structures known as virtual containers. A virtual container (VC) is an information structure within SDH which consists of an information payload and path overhead (POH). There are two types of VC: low order (LOVC) and high order (HOVC). LOVC's (eg. VC-12, VC-2 and VC-3) are for signals of less than 140Mb/s and HOVC's (ie. VC-4) are for 140Mb/s signals.

[0005] With the ever increasing demand for higher data rates there is a continuing need to improve the data transfer capability of networks such as those based on SDH. One way of providing higher bandwidth is concatenation.

[0006] Concatenation is a method for the transport over SDH networks of a payload of a bandwidth greater than the capacity of the defined information structures. ITU standard G.707 defines concatenation as follows: a procedure whereby a multiplicity of virtual containers is associated one with another with the result that their combined capacity can be used as a single data container across which bit sequence integrity is maintained. Two types of concatenation have been proposed: contiguous and virtual.

[0007] Contiguous concatenation is defined in ITU standards such as G.707. Virtual concatenation for VC-2 has also been identified in ITU G.707 but the means for implementing it has not previously been defined and it has therefore not been implemented. Virtual concatenation for VC-4 has been proposed as a concept but no way of implementing has been devised until now. Furthermore, no method of performing conversion between contiguously concatenated signals and virtually concatenated signals has been defined.

[0008] Contiguous concatenation uses a concatenation indicator in the pointer associated with each concatenated frame to indicate to the pointer processor in the equipment that the VC's with which the pointers are associated are concatenated. For example, by contiguously concatenating four VC-4's an information structure with a data rate equivalent to a VC-4-4c could be created. The resulting VC-4-4c equivalent signal has only one path overhead (i.e. 9 bytes only). However many installed SDH networks cannot carry out the necessary processing to support contiguous concatenation. In order to implement contiguous concatenation in such SDH networks it would be necessary to modify the hardware of the equipment in order to handle the concatenated signal. Suitable modification of such a network would be prohibitively expensive.

[0009] This can cause a problem when the customer wishes to transfer data which requires a bandwidth too high for the installed SDH network to handle, such as some broadband services. For example a customer may wish to transfer data in VC-4-4c format but would be unable to transport it over current SDH networks which do not support concatenation.

[0010] The object of the invention is to provide an SDH network with the capability of carrying signals of increased bandwidth. A further object is to provide for the information content of an STM signal carrying data in contiguously concatenated virtual containers to be transmitted over an SDH network not itself capable of carrying contiguously concatenated signals.

[0011] The present invention provides a method for the transmission of data in a synchronous digital hierarchy (SDH) network comprising the steps of transmitting to a node of the network a form of data signal from outside the network, converting the signal into a virtually concatenated information structure and transporting the signal through the network in the virtually concatenated information structure wherein conversion of the signal comprises processing a path overhead of the signal wherein the integrity of the path overhead information is maintained.

[0012] The present invention advantageously provides a method for converting contiguously coneatenated signals into virtually concatenated signals for transport in the network.

[0013] The present invention provides a means for carrying out either of the above methods.

[0014] The present invention also provides a synchronous digital hierarchy (SDH) network in which data is carried in a virtually concatenated information structure, the network comprising tributary cards arranged and configured to process signals received in contiguously concatenated form to convert them into virtually concatenated form for transfer across the network.

[0015] In a preferred embodiment the data transfer is achieved by means of a virtually concatenated information structure equivalent to VC-4-4c comprising a set of four virtually concatenated VC-4 signals. This virtually

concatenated information structure is referred to in the following by the acronym "VC-4-4vc": this being chosen to reflect the fact that the data rate is the same as that of VC-4-4c, with the "vc" indicating virtual concatenation.

[0016] An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which

Figure 1 shows the information structure of a higher order, VC-4 signal of the prior art;

Figure 2 shows part of the structure of a lower order, VC-2 signal of the prior art;

Figure 3 shows the structure of a lower order, VC-12 signal of the prior art.

[0017] Referring to Figure 1, this shows synchronous transfer module STM comprising a section overhead SOH, a pointer and a virtual container VC. The VC in turn comprises a path overhead POH, fixed stuff bytes and a container C for the payload.

[0018] A network management system manages the transfer of virtually concatenated VC-4's without any modification being required to network equipment. The only hardware modification required is the provision of modified tributary cards capable of identifying the receipt at the network boundary of contiguously concatenated VC-4's and processing them accordingly. Individual VC-4's and virtually concatenated VC-4's are transported in the SDH network in the same way. Hence, four VC-4's, when virtually concatenated, will still have four path overheads.

[0019] In the standard configuration a tributary card accepts at its input and delivers at its output an STM-4 signal containing four independent VC-4's (by way of example, each may contain a 140Mb/s, 3 x 34Mb/s or 63 x 2Mb/s mapped PDH signals). However, the new tributary card is also capable of accepting at its input and delivering at its output an STM-4 signal containing four contiguously concatenated VC-4 signals: as for example may arise from mapping ATM cells into STM-4 to ITU recommendations I.432 and G.707.

[0020] The tributary card will recognise the format of the incoming STM-4 signals: as a contiguously concatenated signal using the concatenation indication in the pointer and act accordingly.

[0021] Optionally, the tributary card could also be configured to handle STM-4 signals containing four virtually concatenated VC-4 signals, to meet future demand. The tributary card STM-4 interface meets the requirements of G.957 and G.958. The transport of the ATM/STM-4 signal over the SDH network is transparent and SDH parameters processing and performance monitoring shall apply according to G.826, G.707, G.783 and ETS300 417.

[0022] At the ATM/STM-4 input port the pointers of the four concatenated VC-4's are aligned. The resulting, newly generated four VC-4's are processed for transfer across the network as a virtually concatenated information structure (VC-4-4vc) signal by processing their associated path overheads as follows.

[0023] Whereas the pointer can indicate delay of the concatenated VC-4's in the VC-4-4vc of up to one frame duration (i.e. 125 μs) higher delays cannot be picked up in this way. Since the differential delay between the VC-4s of a VC-4-4vc as they are transported across the SDH network are unknown, it is necessary to take steps to ensure that the VC-4s so transferred are in the correct sequence. The path trace (J1) value for each of the VC-4's in the VC-4-4vc is given a unique code indicating their order within the VC-4-4vc.

[0024] It is also necessary to ensure that the frames of each VC-4 in the VC-4-4vc are correctly ordered. The H4 byte is therefore used for frame sequence indication (FSI) to allow the network to recover the original sequence.

[0025] A signal label code is inserted in the C2 byte of each VC-4 of the VC-4-4vc to indicate the payload type, eg an ATM payload as required. The B3 byte of the received contiguous VC-4-4c signal is processed, as appropriate, to maintain the path integrity.

[0026] On the back-plane port of the network node which receives the VC-4-4vc signal the virtually concatenated VC-4's of the VC-4-4vc are aligned using a buffer according to the information provided by the path trace values and the frame sequence values. The size of the buffer is dependent on the maximum differential delay allowed between the VC-4's which constitutes the VC-4-4vc. A value of 8 milliseconds is proposed, by way of example, based on the use of the H4 byte to indicate the frame sequence. However such a buffer size may prove prohibitively large. Therefore it may be necessary to reduce the buffer size by ensuring that the differential delay is kept to the absolute minimum. This may be achieved by ensuring that the four VC-4's in the VC-4-4vc are processed and switched together as well as being transmitted together in the same synchronous transfer module (STM), e.g. STM-4, STM-16, STM-64, and along the same route through the network.

[0027] Path trace mismatch on any of the VC-4 in the VC-4-4vc will result in trace mismatch defects on the VC-4-4vc signal. Similarly, signal label mismatch and loss of signal (LOS) of any VC-4 in the VC-4-4vc will result in alarm indication signal (AIS) in the VC-4-4vc.

[0028] The contents of the pointers, concatenation indicators and path overhead bytes of the contiguous concatenated VC are transported in other bytes or bits in the virtually concatenated VC. Suitable unused bits include some path overhead bytes of the virtually concatenated VC that are assigned to functions not used during virtual concatenation and the fixed stuff bits of the container four (C4) that forms part of the VC-4.

[0029] The pointers, concatenation indicators and path overhead bytes must be restored as appropriate

before the signal is transmitted as a contiguous signal outside the network. The path overhead information in the first VC-4 frame in the received virtual concatenated VC-4-4vc signal is inserted in the path overhead of the contiguous concatenated VC-4-4c signal generated by the network for transmission outside the network. Additionally, the B3 value is corrected as appropriate to maintain the path's integrity and is inserted in the contiguous VC-4-4c path overhead. Thus the output port delivers an STM signal identical to that presented at the input port.

[0030] In a typical system performance reports and alarms would be passed to the element manager (EM). The EM (and SDH network management system) may be required to configure the VC-4's which constitute the VC-4-4vc in a preferred manner.

[0031] The invention is not limited to only VC-4-4c or VC-4-4vc. The invention applies to any number of VC-4s (ie. VC-4-nc or nvc where n may be in the range of 2-64 or higher)

[0032] The above embodiment is described by way of example only and does not limit the scope of the invention. In particular the present invention applies equally to signals and information structures other than VC-4, for example to VC-3, VC-2 and VC-1. Virtual container signal structures (including VC-4, AU3/VC-3, TU3/VC-3, VC-2 and VC-12) are defined by the ITU, for example in ITU-T G.707 (Draft) 11/95 published 1995.

[0033] The arrangement and method of this invention as described above in relation to VC-4 also applies to VC-3 signals. In particular the path overhead of these two signals is exactly similar, allowing the same method for processing of overhead bytes to be used for both types of signal. This applies equally to administrative unit three (AU3) VC-3 as to tributary unit three (TU3) VC-3 signals.

[0034] Referring to Figure 2, this shows part of the structure of a lower order virtual container VC-2. In Figure 2 only the first column of the VC-2 is shown to illustrate the positioning of the path overhead (POH) bytes V5, J2, N2 and K4. Also shown are fixed stuff bits R and data bits D. The fixed stuff bits of the first column make up eight whole bytes and other stuff bits and bytes are included in subsequent columns (not shown). The subsequent columns (not shown) comprise further data bits and bytes, together with overhead bits, justification opportunity bits and justification control bits the precise function of which is not relevant to the present disclosure but is detailed in the above ITU-T publication.

[0035] Referring to Figure 3, this shows the structure of a lower order virtual container VC-12 with path overhead (POH) bytes V5, J2, N2 and K4. Data is carried in three units of 32 bytes plus one unit of 31 bytes. Other bytes are variously made up of fixed stuff bytes R, overhead bits O, justification opportunity bits S, justification control bits C and data bits D. The fixed stuff bits R make up five whole bytes and parts of three other bytes with a total of 49 bits. The precise functions of the other bits are not relevant to the present disclosure but are also detailed in the above ITU-T publication.

[0036] With lower order VCs (ie VC-2s and VC-1s) the conversion of the path overhead bytes will be slightly different. Accordingly to the invention, the contents of the V5, J2, N2 and K4 overhead bytes of the contiguous concatenated VC-2 and VC-1 signals (e.g. VC-2-5c or VC-12-4c), are transported in other bytes or bits in the virtually concatenated VC-2s/VC-1s. Suitable unused bits are the fixed stuff bits R or overhead bits O. These overhead bytes are restored before the signal is retransmitted as a contiguous signal outside the network.

[0037] Thus VC-4, VC-3, VC-2 and VC-1 can all be transmitted as virtually or contiguously concatenated signals over ATM or PDH networks.

Claims

1. A method for the transmission of data in a synchronous digital hierarchy (SDH) network comprising the steps of transmitting to a node of the network a form of data signal from outside the network, converting the signal into a virtually concatenated information structure and transporting the signal through the network in the virtually concatenated information structure wherein conversion of the signal comprises processing a path overhead of the signal wherein the integrity of the path overhead information is maintained.

2. The method of Claim 1 comprising the step of converting the signal so transported into a signal of the same form as that transmitted to the network wherein conversion of the signal comprises processing a path overhead of the signal wherein the integrity of the path overhead information is maintained.

3. The method of any one of the above claims wherein the signal transmitted to the network from outside the network is in contiguously concatenated form.

4. The method of any one of the above claims wherein the data signal from outside the network comprises a virtual container four (VC-4) or virtual container three (VC-3).

5. The method of Claim 4 wherein the path overhead comprises bytes H4, J1 and B3; and the VC-4 and VC-3 comprise a plurality of frames, the step of processing the path overhead including the steps of using byte H4 for indicating frame sequence within the VC-4 or VC-3 using byte J1 to indicate the order of VC-4s or VC-3s in a virtually concatenated information structure and correcting, as necessary, the error indication information carried in byte B3.

6. The method of Claim 5 comprising the steps of

transmitting to a node of the network a signal from outside the network in a form comprising four contiguously concatenated VC-4s and processing the four VC-4s into a virtually concatenated information structure comprising virtually concatenated VC-4s for transfer across the network.

7. The method of Claim 5 comprising the steps of transmitting to a node of the network a signal from outside the network in a form comprising five contiguously concatenated VC-3s and processing the five VC-3s into a virtually concatenated information structure comprising virtually concatenated VC-3s for transfer across the network.

8. The method of anyone of Claims 6 or 7 comprising the step of signing the virtually concatenated virtual containers (VCs) of the virtually concatenated information structure using a buffer.

9. The method of Claim 8 comprising the step of controlling the alignment according to the contents of bytes J1 and H4.

10. The method of any one of Claims 6 to 9 comprising the steps of switching and transmitting the VC-4 or VC-3 frames of the virtually concatenated information structure through the network together in a single synchronous transfer module (STM) or in multiple STMs and via the same route.

11. The method of any one of Claims 1 to 3 wherein the data signal from outside the network comprises a virtual container two (VC-2) or a virtual container one (VC-1).

12. The method of Claim 11 wherein the path overhead comprises bytes V5, J2, N2 and K4 and wherein the step of processing the path overhead includes the step transferring the contents of the path overhead bytes to unused parts of the signal.

13. The method of Claim 12 comprising the steps of transmitting to a node of the network a signal from outside the network in a form comprising two or more contiguously concatenated VC-2s or VC-1s and processing the VC-2s or VC-1s into a virtually concatenated information structure comprising virtually concatenated VC-2s or VC-1s for transfer across the network.

14. The method of Claim 13 comprising the step of aligning the virtually concatenated VCs of the virtually concatenated information structure using a buffer.

15. The method of Claim 14 comprising the step of controlling the alignment according to the contents of the path overhead bytes transferred to the unused parts of the signal.

16. The method of Claim 13 in which the contiguously concatenated VC-2s or VC-1s received from outside the network comprise a plurality of frames in a set sequence, and in which the sequence of the frames may change whilst being transported through the network, the method comprising the step of re-ordering the frames into the set sequence as required.

17. The method of any one of Claims 13 to 16 in which the VC-2s and VC-1s comprise a plurality of frames, the method comprising the steps of switching and transmitting the VC-2 or VC-1 frames of the virtually concatenated information structure through the network together in a single synchronous transfer module (STM) or in multiple STMs and via the same route.

18. The method of any one of the above claims comprising the step of recognising the receipt of a signal in concatenated form by the network.

19. A means for carrying out the method of any one of the above claims.

20. A synchronous digital hierarchy (SDH) network in which data is carried in a virtually concatenated information structure, the network comprising tributary cards arranged and configured to process signals received in contiguously concatenated form to convert them into virtually concatenated form for transfer across the network.

21. The network of Claim 20 wherein the tributary cards are arranged and configured to process signals transferred across the network in virtually concatenated form and to convert them into contiguously concatenated form.

22. The network of Claim 21 wherein the signals in virtually concatenated form comprise virtual containers (VC) and the tributary cards comprise one or more buffers for aligning said virtual containers (VC).

23. The network of any one of the Claims 20 to 22 wherein the tributary cards are configured and arranged to detect the receipt of signals in contiguously concatenated form by detecting a concatenation indication of the signals received.

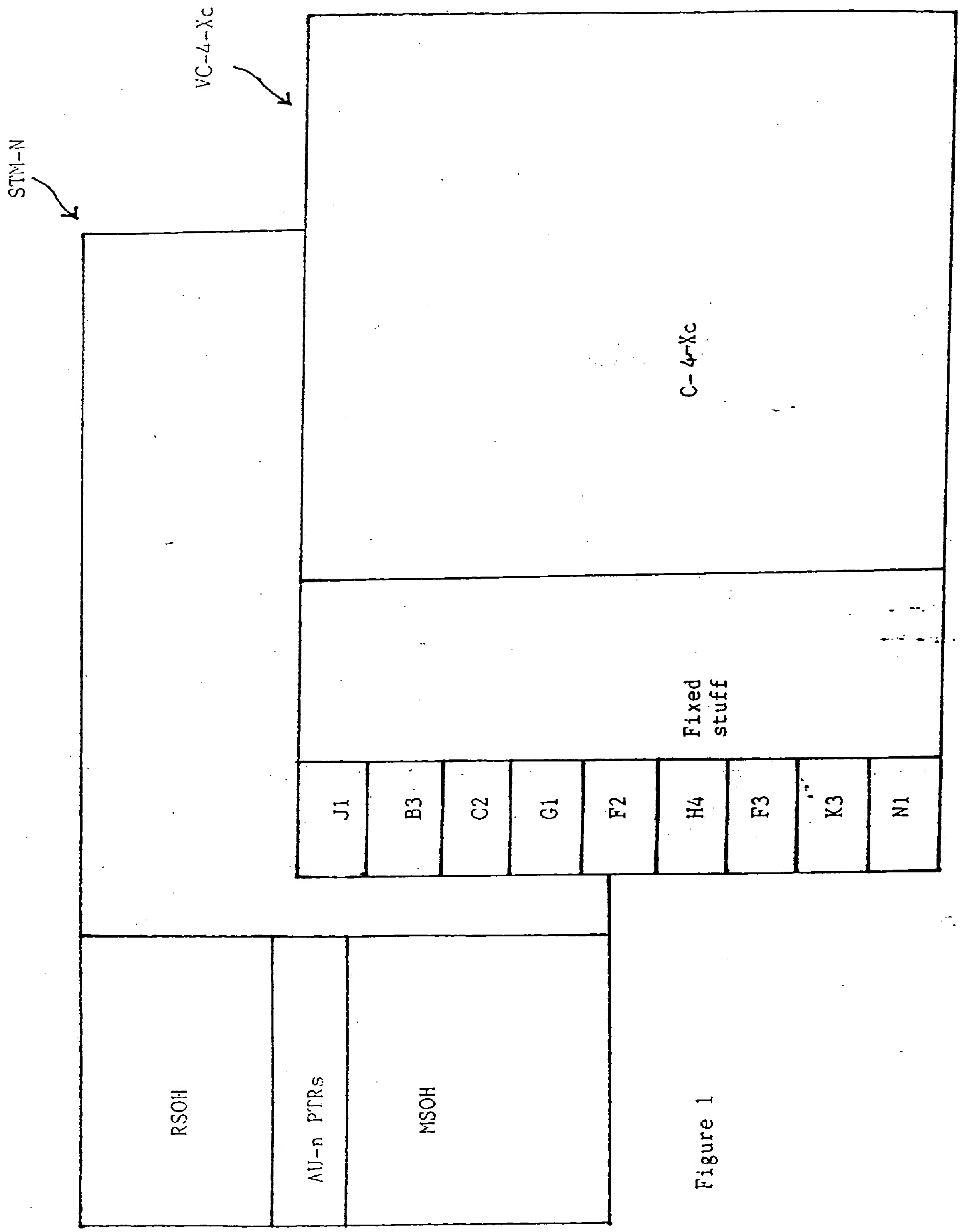
VC-4-Xc
STM-N
C-4-Xc
Fixed stuff
J1
B3
C2
G1
F2
H4
F3
K3
N1
RSOH
AU-n PTRs
MSOH

Figure 1

V5
R R R R R R R R
D D D D D D D D
R R R R R R R R
J2
R R R R R R R R
D D D D D D D D
R R R R R R R R
N2
R R R R R R R R
D D D D D D D D
R R R R R R R R
K4
R R R R R R R R
D D D D D D D D
R R R R R R R R

Figure 2

V5
R R R R R R R R
32 BYTES
R R R R R R R R
J2
C_1 C_2 O O O O R R
32 BYTES
R R R R R R R R
N2
C_1 C_2 O O O O R R
32 BYTES
R R R R R R R R
K4
C_1 C_2 R R R R R S_1
S_2 D D D D D D D
31 BYTES
R R R R R R R R

Figure 3